The Optimization and Experimental Study of Auto-Cascade Refrigeration System

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Abstract. Auto-cascade refrigeration system using multiple non-azeotropic refrigerants, taking advantage of the difference between the evaporation temperature of high and low boiling point components, applying the single-stage compression, by the way of internal cascade to obtain a larger working temperature range, and a lower environment. This paper uses the minimum entropy production method to improve the experimental device. By the way of checking the leakage of the experimental system, to analyze the influence caused by the leakage of different components of the system. So that the refrigeration efficiency and the stability of the system have been improved and the result of the research has a good application prospect.

Introduction

Auto-cascade refrigeration system using single-stage compression, taking advantage of the principle of different boiling point of the mixed working fluid, by the way of multistage segregation, to make the mixed working fluid separated gradually and finally achieve a lower temperature. In which way, largely simplified the multilevel cascade refrigeration system [1]. In this system, the high boiling point working medium can be condensed into liquid at high temperature, through the throttle to the low pressure pipe; this can avoid the high boiling point medium with solid precipitation in the low pressure pipe, and reduce the possibility of blocking the throttling parts. The security, reliability of the system has been improved [2]. At the same time, this method has also reduced the lower heat load, which means the flow loss and heat loss of the high boiling point working medium in the low temperature zone have reduced [3], backing to the thermal efficiency is improved, and the system's COP is also improved. The automatic cascade system has not been widely used in business; the basic reason is that the system's COP value is too low. Although it is possible to achieve low temperature, the system's running and maintenance expense is too great. There are many factors influence the COP of the system, first of all, according to the simulation to

set up the reasonable system solutions. Firstly, though experiment verify its rationality, and according to the actual experimental results combined with the system optimization.

experiment operation and improvement

Leak detection of the system

Mixed working medium from the cascade system's biggest drawback is leaking at runtime, making the refrigerating capacity insufficient, and cannot accurately know what kind of refrigerant to add, add ratio also can not be calculated. Leak detection of the system is very essential, otherwise the system is nonsense, and unable to achieve the real effect by experiment, ratio and filling volume are all invalid. According to refrigerant distribution location when the system is running, analysis different parts of the impact on the system caused by the leak, estimate the amount of refrigerant complement the actual process can be implemented.

R22、R23、R14 Running test

Calculate the mass flow rate of low temperature refrigerant according to the refrigerating capacity of the system need, achieving the mass flow rate of the medium temperature refrigerant according to the condensing heat of the low temperature refrigerant; similarly get the mass flow rate of the high temperature refrigerant. Calculate the mass flow rate of all kinds of refrigerants and the time for one cycle, as well as the volume of all components of the system, according to the refrigerant proportion of each part in Freon system, to calculate the refrigerant filling quantity of each part.

（1）Filling R22 before starting the unit, the filling amount depends on when the liquid level can be seen in the first separator. Running the unit for a while, start the second step after the unit can normally operate. Otherwise, find out the reason, write down the filling quality of R22.

（2）Filling R23 after starting the unit, the filling quality is calculated by calculation rate of R23/R22, running the unit for a while, then measure the temperature at the end of the evaporation coil, checking whether it can reach the predicted value(-60℃) or not.

（3）Filling R14 after starting the unit, the filling quality is calculated with the reference to the second step. Be especially careful when filling pressure changes, after filling R14 the unit pressure rise immediately, we need to protect ourselves carefully, slow down when filling R14 and focus on the pressure changes at the compressor outlet. After the unit operating for a period of time, measure whether the temperature of the evaporation coil has reached -100℃.

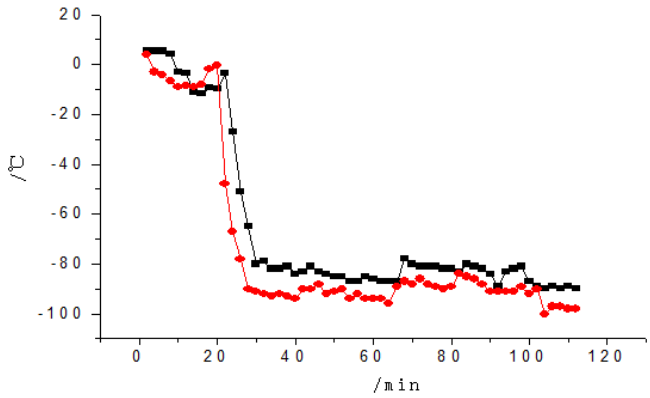

Figure 2-1 Evaporation coil cooling curve

Figure 3-2 is the temperature diagram of the whole stable system. The figure 3-3 shows that when the experiment began 25 minutes, the temperature drops rapidly within the evaporator; when the experiment began 30 minutes, the temperature decreasing speed of the evaporator is relatively slow; The temperature of the evaporator remains stable within 2 hours, achieving the lowest temperature of -110 ℃[6]. The system is idle during the experiment, none items was frizzed, Due to the small amount of the cold quality, the evaporation of R14 is very few, and it may not completely separate in the separation process, there are few R23 in R14, the refrigerating agent can cool itself caused the phenomenon of the temperature of back gas is lower than the temperature of feed liquid.

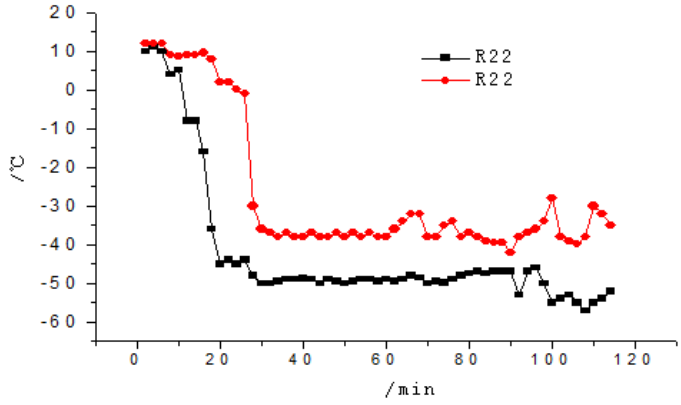

Figure2-2E2 separation tank evaporation curve of R22 refrigerating agent

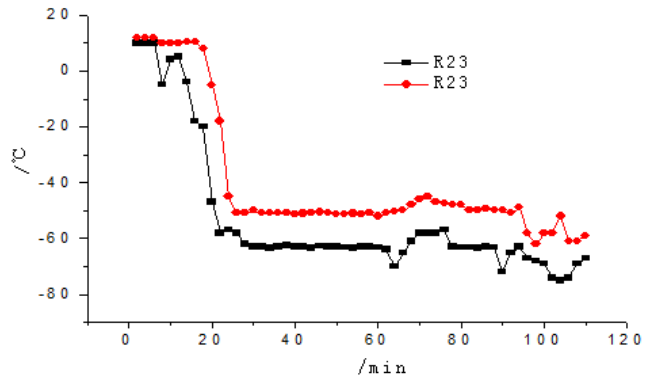

Figure2-3 E3 separation tank R23 cooling evaporation curve

The figure shows that the temperature change of the serpentine coil in E2 separator is big after the unit operating 10-20 minutes; the main reason is that at the beginning operation of the compressor, the mixed working fluid is still in mixed state, each component is not isolated, the temperature change is relatively slow. After the unit running 10 minutes, R22 medium begins to be condensed by water, flows from the bottom of E1 tank, after the throttle in the serpentine coil evaporation condensation R23, began to quickly reduce the temperature.

System analysis and improvement

After filling the appropriate amount of refrigeration, the temperature is still not ideal, even shows the disorder phenomenon. Analyze each equipment's influence on the temperature of the system, according to the change of the temperature for replacement of the units.

The thermal expansion valve

The critical pressure of the refrigerant in this system is relatively high, so there are higher requirements for compressor and pipe line, especially for the thermal expansion valve, we need to replace the appropriate throttle valve, adjusting the opening degree of the throttle, to achieve the low temperature.

Lubricating oil

In the refrigeration system, the main function of lubricating oil is for lubrication, sealing, cooling, etc. The main consideration for selecting lubricating oil is its low temperature performance and its intersolubility with refrigerants. What is most important for the lubricating oil of this experiment is it can still remain a good flow property under low temperature conditions. Finally according to the type of refrigerant selected choose suitable lubricating oil [7].

Summary of the system operation: Poor refrigeration ability, low exhaust temperature, evaporation temperature drops. Supposing that the dirt and oil mix into a paste mucus blocks the tiny channels (such as filter and capillary). Especially in the low temperature components due to its viscosity is bigger, so it is easier to jam [8].

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